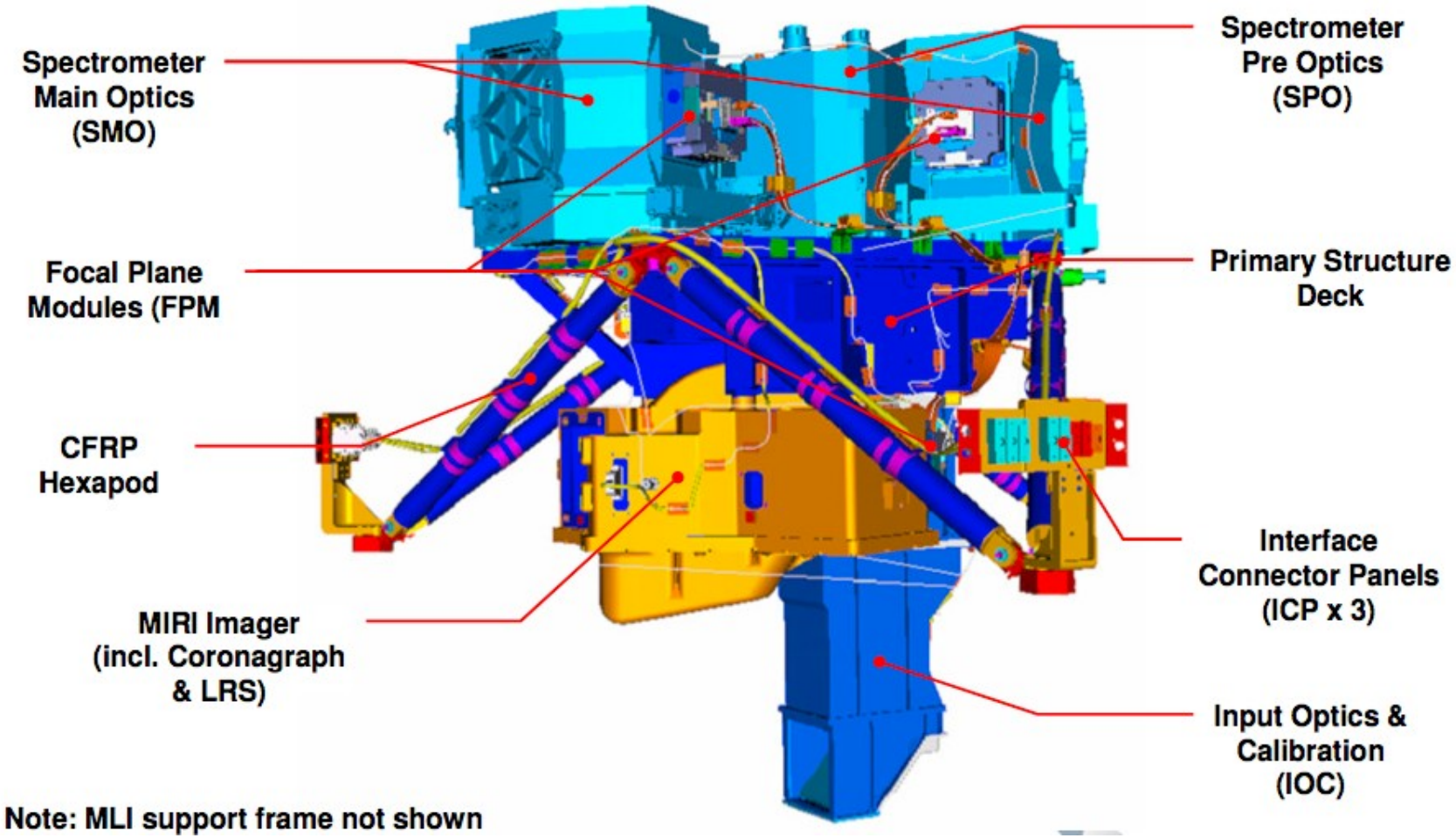
JWST MIRI

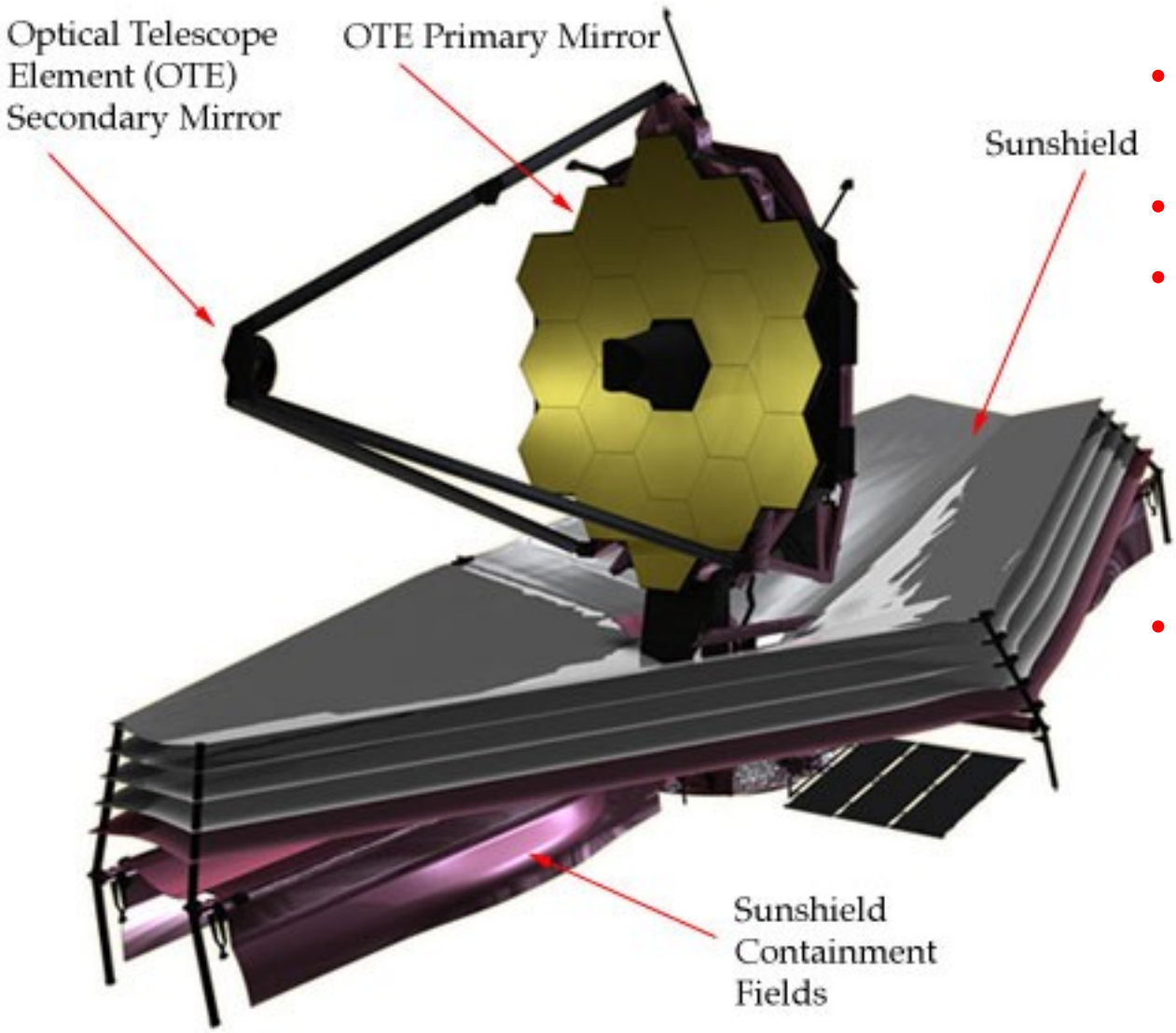


SOFIA Community Task Force

T. Greene (NASA ARC)

9 September 2009

JWST in a nutshell

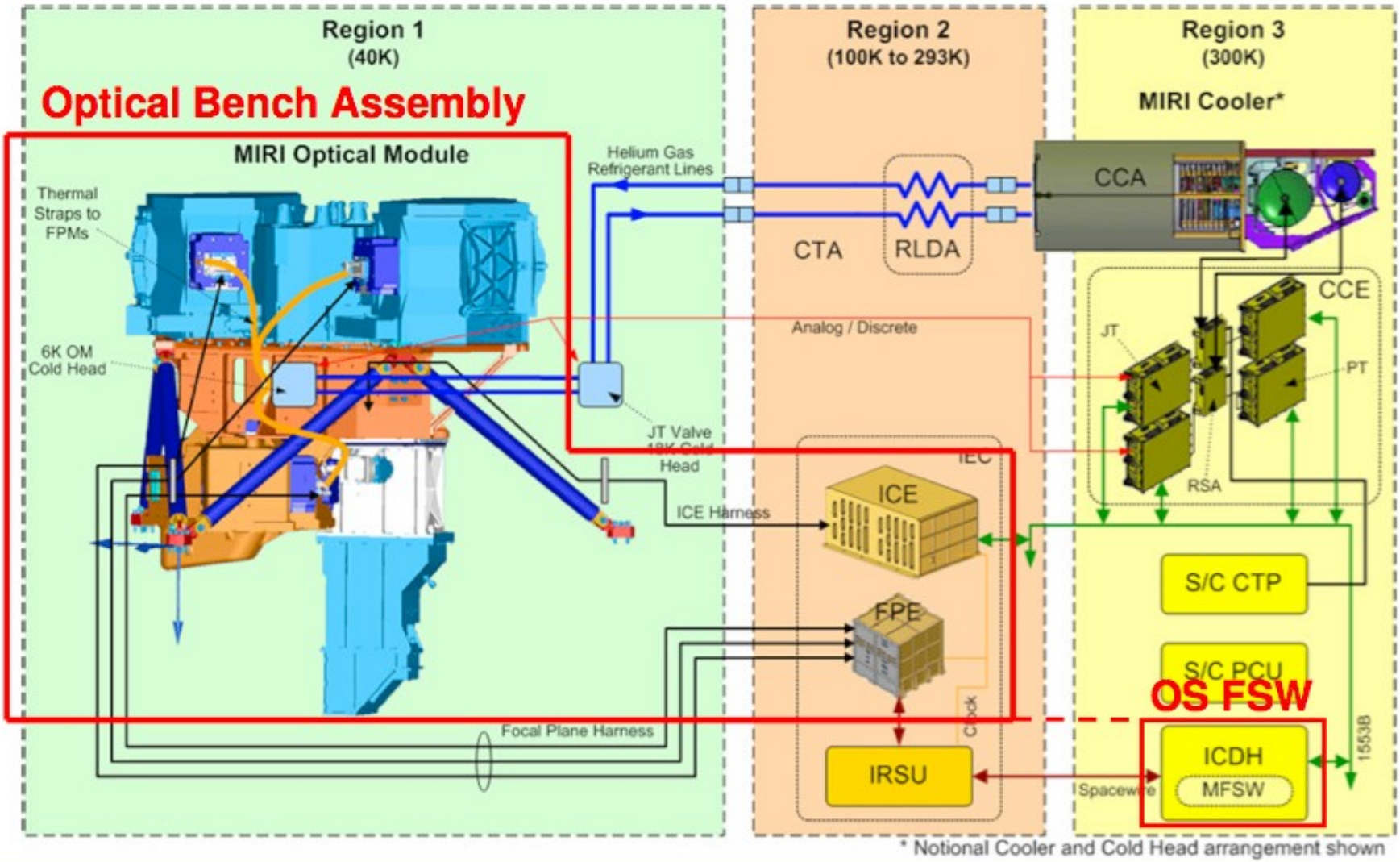


- 6.5-m primary mirror; 18 segments
- λ ~1 - 28 μm
- Instruments:
  - NIRCam
  - NIRSpec
  - MIRI (cam + spec)
  - FGS w/TF
- 2014 launch
  - Arianne V to L2
  - 5 yr req life
  - 10 yr goal
  - No cryogens

JWST Transit Capabilities: Instruments (2)

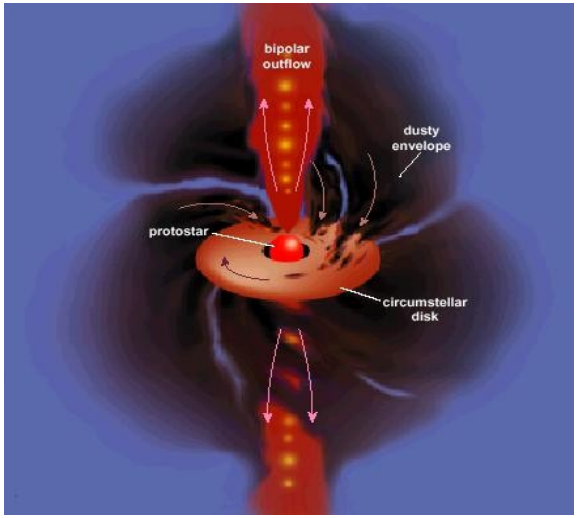
- **NIRCam:** 1 – 5 μm images & some spectra
  - Images over 0.7 – 5 μm Nyquist sampled at 2 and 4 μm
  - R ~ 1700 spectra 3 – 5 μm (not continuous)
  - K ~ 5 - 8 bright limit via subarrays, weak lenses, spectra
- **NIRSpec:** 1 – 5 μm spectra
  - R=100 (1 setting) and R=2700 (3 settings) spectroscopy with coarse (100 mas) spatial sampling for single or multiple objects
  - Implementing a very wide slit (1.6 arcsec) to eliminate slit modulation
- **MIRI:** 5 – 28 μm images & spectra
  - 5 – 28 μm Imager Nyquist sampled at 7 μm
  - Low Res Spectrograph R~100 λ = 5 – 10 (14) μm
  - Med Res R=3000 Integral Field image slicer spectrograph
- **Fine Guidance Sensor** Tunable Filter (FGS TFI)
  - 1 – 5 μm images
  - Has a coronagraph; using masks alone reduces diffraction

MIRI Block Diagram

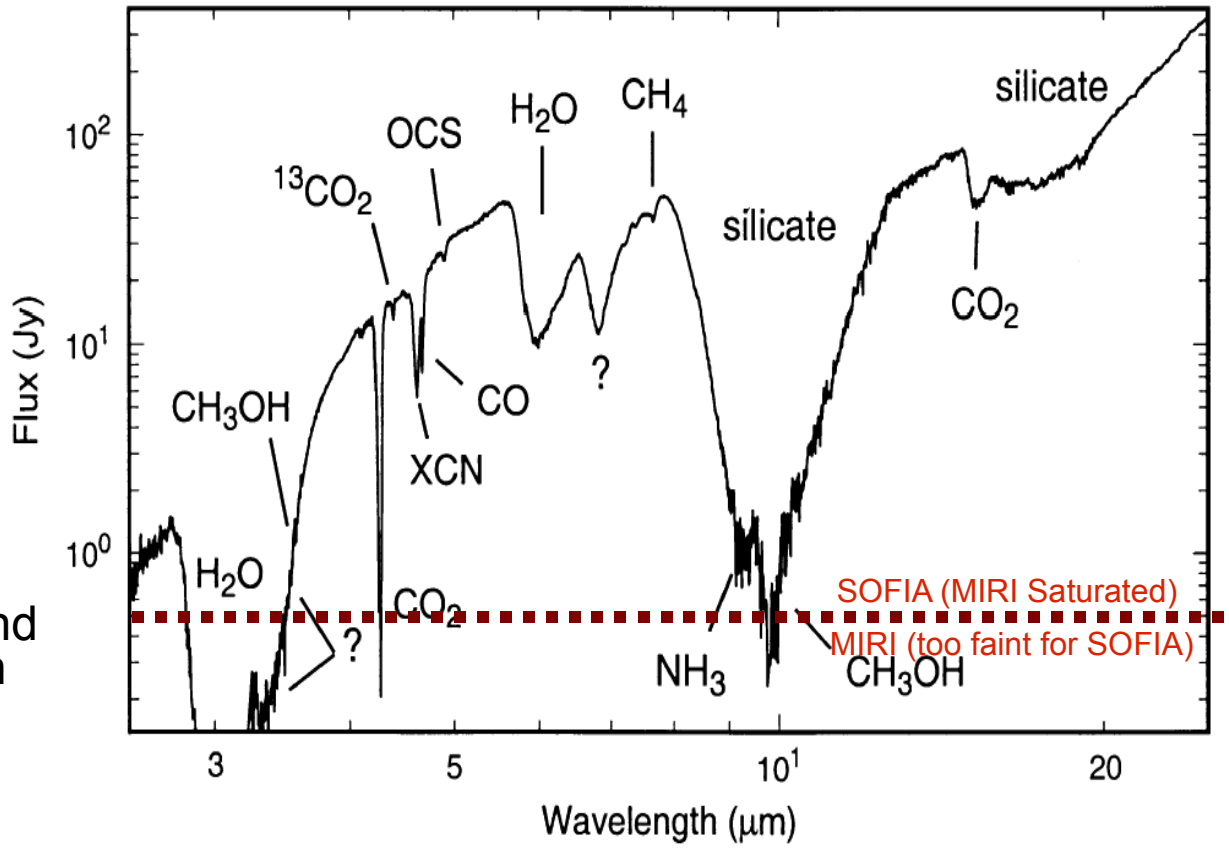


MIRI & SOFIA: Complimentary Dynamic Range

Objective: Study the inventory and processing of organic matter in protostellar envelopes via absorption spectroscopy.



Absorption from silicates and H_2O, CH_4 and NH_3 are seen along lines of sight to protostars embedded in molecular clouds.
(ISO SWS Spectrum of W33A, Gibb et al. 2000)



MIRI Exoplanet Sec. Eclipse Sensitivity

Table 1: Exoplanets 0.1 AU from a G2V star at 15 pc distance

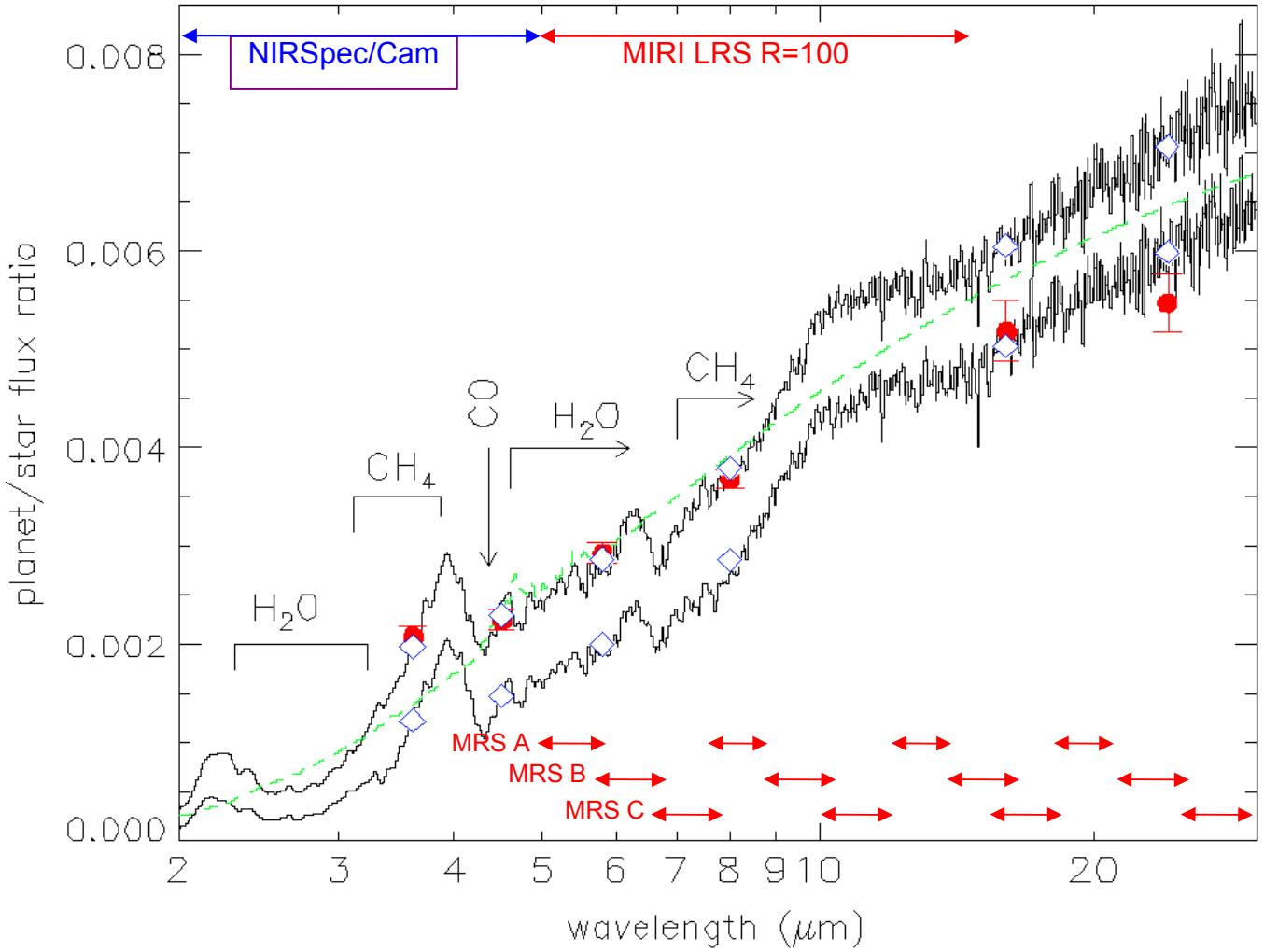
Planet	F1000W R=5	F2100W R=4	LRS@10 μm R=30
1 R_{Jup} Itime (hr) S/N=30	0.1	0.1	1
1 R_{Jup} contrast	8E-4	1.5E-3	8E-4
2 $R_{\oplus}$ Itime (hr) S/N=5	3	4	19
2 $R_{\oplus}$ contrast	2.7E-5	5E-5	2.7E-5

Table 2: Exoplanets 0.05 AU from a M5V star at 10 pc distance

Planet	F1000W R=5	F2100W R=4	LRS@10 μm R=30
1 R_{Jup} Itime (hr) S/N=30	4.6	0.4	36
1 R_{Jup} contrast	3E-4	2E-3	3E-4
2 $R_{\oplus}$ Itime (hr) S/N=5	118	11	925
2 $R_{\oplus}$ contrast	1E-5	7E-5	1E-5

- Planets 0.1 AU from G2 star have 12 day periods and T ~ 890 K
- Planets 0.05 AU from M5 star have 9 day periods and T ~ 290 K
- Integration times are lower limits for secondary eclipse observations – no systematic noise or overheads included

Spitzer / JWST views of HD 189733b



CH4, CO, H2O constrain temperature and C abundance

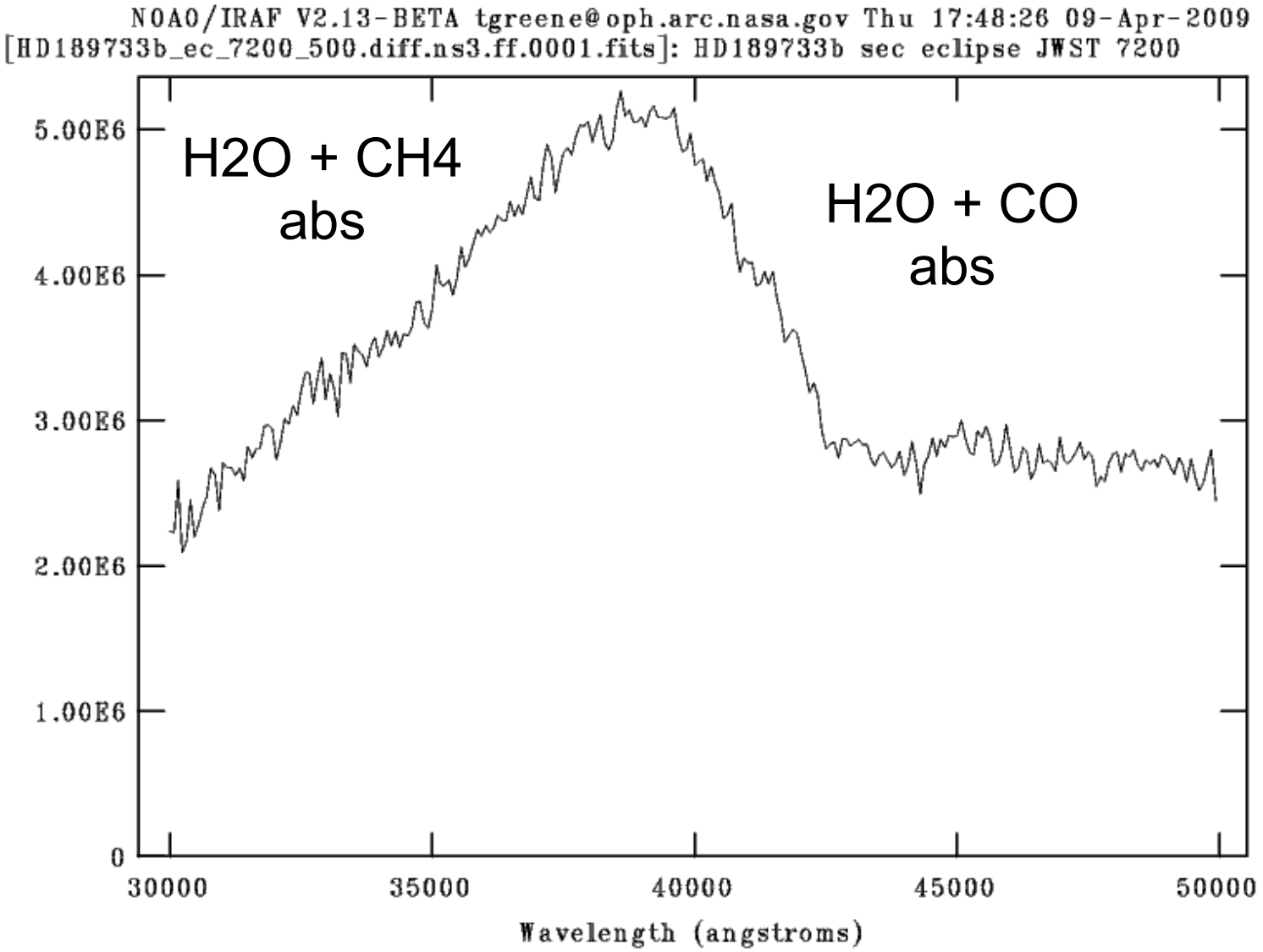
Red symbols are measurements;

Top curve has flux absorbed on day side only; bottom has uniform energy redistribution

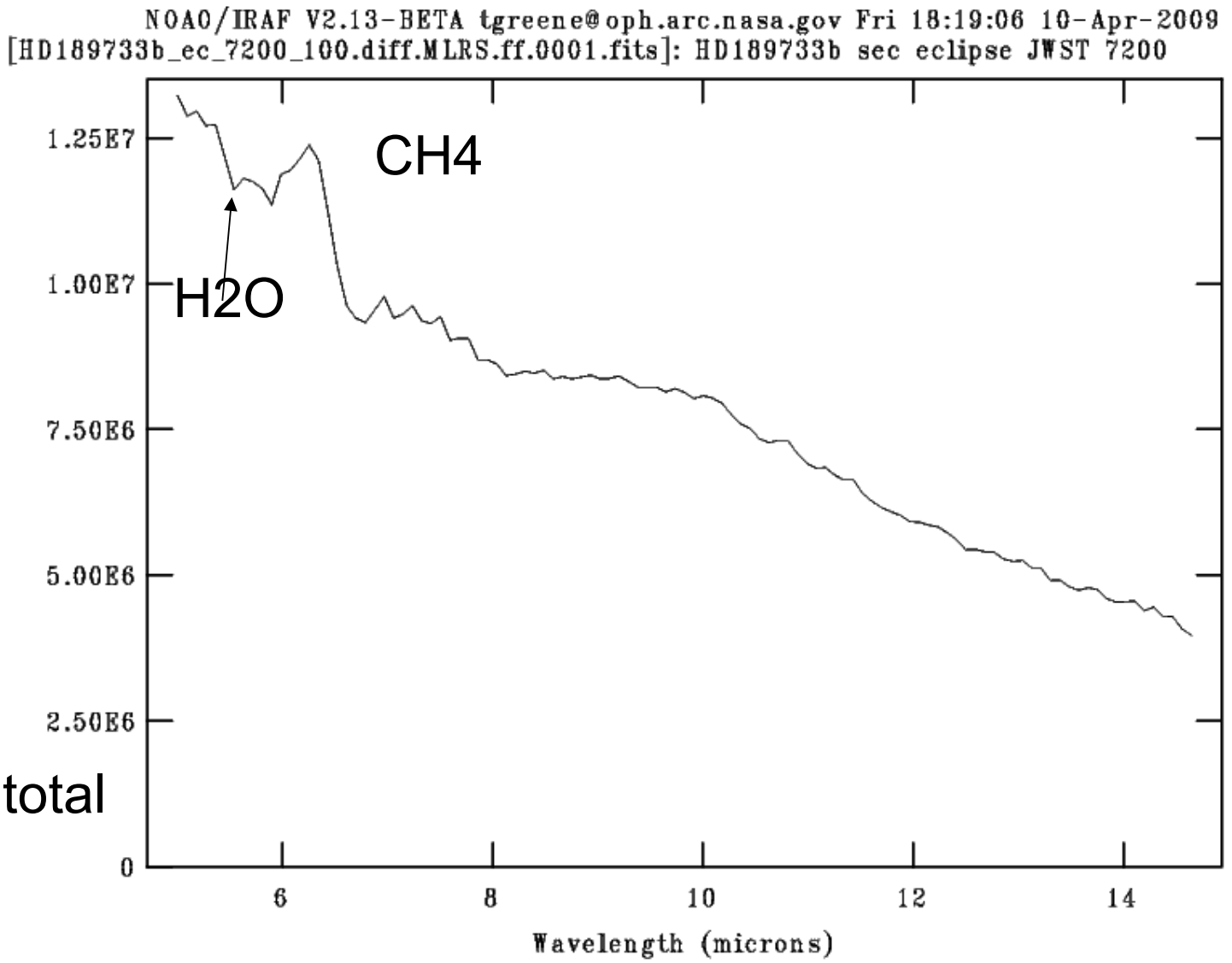
Dashed line is BB

Charbonneau, Knutson, Barman, Allen, Mayor, Megeath, Queloz, & Udry (2008)

HD 189733b nIR Sec. Eclipse

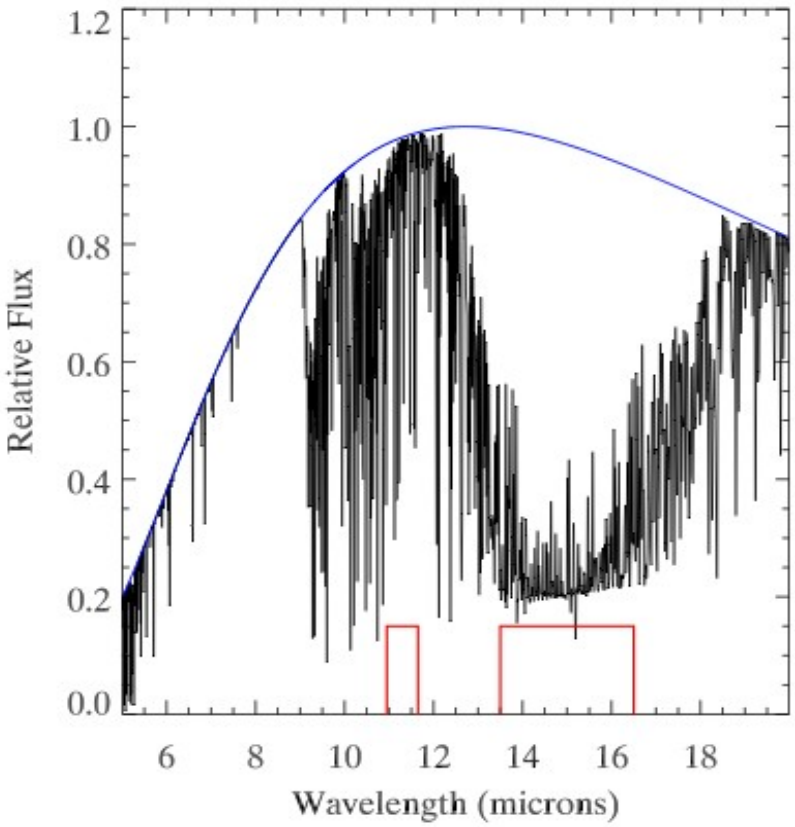


HD189733b MIRI LRS R=100 simulation



t = 4 hr total

MIRI detection of CO_2 abs. in Super-Earths

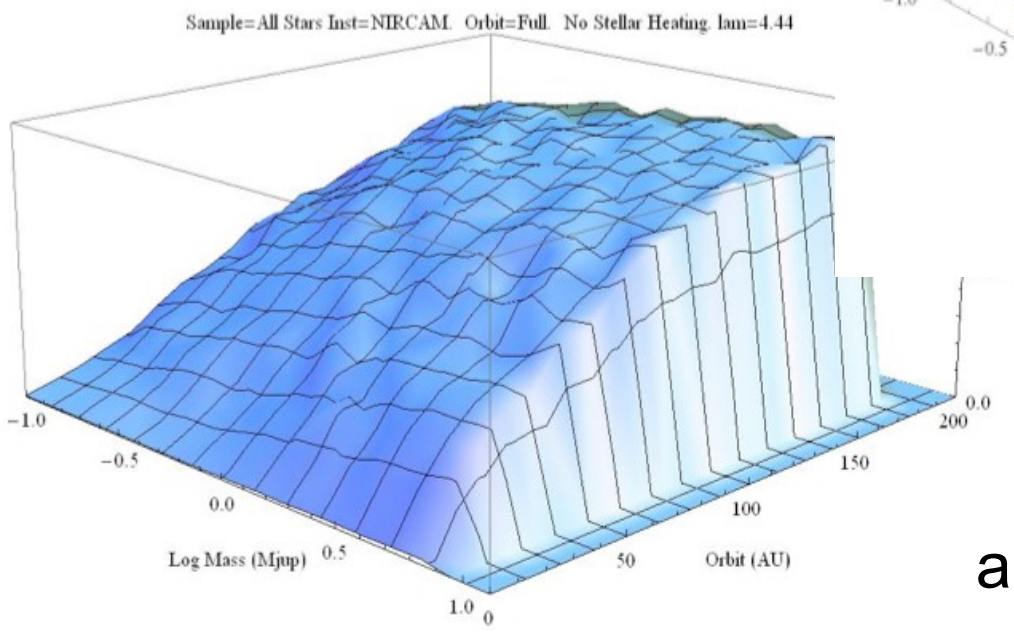


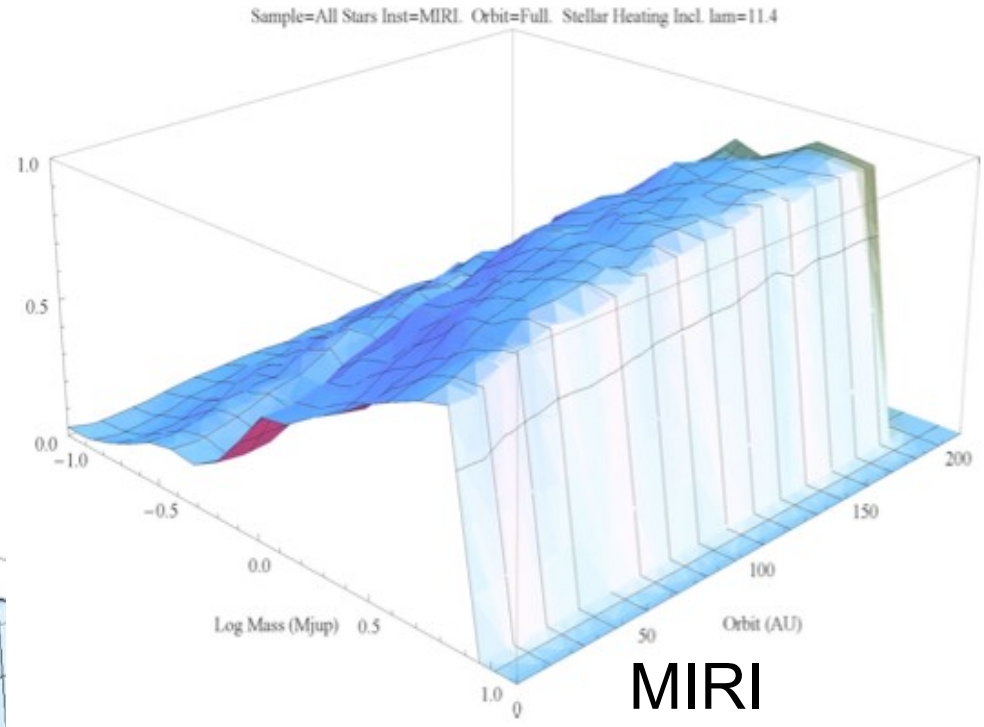
Deming et al. (2009) showing Miller-Ricci Super_Earth (2009) and MIRI filters

- JWST MIRI filters (red boxes, left) can be used to detect deep CO2 absorption in Super-Earth atmospheres (Miller-Ricci 2009 model, left)
- Modelling shows that modest S/N detections possible on several TESS-discovered planets (Deming et al. 2009).

MIRI and NIRCAM planet imaging detectability

NIRCam





MIRI

all Beichman et al. 2009